Exotic, Emerging, Re-Emerging and Invasive Plant Diseases of Horticultural Crops

ARS LOCATION:
Horticulture Crops Research Laboratory
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PRINCIPAL INVESTIGATOR:
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PROJECT OBJECTIVES:

1. Describe the pathogen biology of exotic, emerging, re-emerging, and invasive plant pathogens affecting horticultural crops.
2. Characterize host ranges and levels of resistance of hosts to exotic, emerging, re-emerging, and invasive plant pathogens affecting horticultural crops.
3. Apply knowledge of biology, ecology, and epidemiology to the development of improved integrated disease management approaches.

MAJOR ACCOMPLISHMENTS (2007–2010):

Timing Fungicide Applications based on Inoculum Detection:
The Pacific Northwest grape powdery epidemics do not always appear to be initiated following conditions suitable for ascospore release, thus indicating that overwintering inoculum is not always present. We have developed qualitative and quantitative PCR approaches for detecting airborne inoculum and demonstrated that delaying fungicide application until detection does not increase disease development despite eliminating 2.4 fungicide applications in commercial vineyards. **Impact:** The reduction in the fungicide use will increase the economic and environmental sustainability of vineyards. In addition, the quantitative data in airborne inoculum concentration could be used to improve disease models for predicting timing of fungicide and further reducing pesticide use. The reduction sulfur use could also result in increased beneficial insects populations and reduced insect damage. (Collaborator Gary Grove)

Use of interpolated weather and forecast data for disease forecasting models:
The costs of establishing and maintaining weather stations and the lack of site specific forecast data often limit grower utilization of disease and pest forecasting models to time pesticide applications. A collaborative group of meteorologists, climatologist, entomologist, plant pathologist, and information specialists have developed methods for high resolution downscaling of weather and forecast data and demonstrated their suitability for running the Gubler/Thomas infection Risk model in Oregon. **Impact:** The downscaled data gives growers more precise information regarding the various microclimates of their production area which could potentially lead to precision application of fungicide based on the variable risk of infection in a vineyard. The growers save time and money by not having to maintain and analyze their own weather data or could use a lower station density. The increased use pest models could reduce pesticide application while improving pest management. The downscaled data could also be used by the general public for numerous other activities such as

transportation and construction scheduling. (Collaborators Gary Grove, Leonard Coop, Chris Daly, Paul Jepson, Allan Fox, David Gent, William Pfender, Doug Gubler, Travis Lybbret, and Carla Thomas).

Early season fruit zone leaf removal:
Removal of leaves from the fruiting zone is a common practice in most western vineyards to aid in disease management post bloom. However, there could be benefits with earlier removal. Two years of commercial vineyard trials have demonstrated that leaf removal when inflorescences are separating resulted in significant reduction disease incidence without impacting fruit quality or yield. **Impact:** Growers appear to have a longer window of opportunity in which leaf removal can be conducted with impacting fruit quality. Earlier leaf removal appears to result in less powdery mildew and botrytis bunch rot development thus improving growers' ability to meet fruit quality targets. (Collaborator Patty Skinkis)

Grower performed LAMP PCR:
Inoculum detection for timing fungicide applications has been shown to reduce fungicide use but requires significant capital equipment ($45,000) and highly skilled labor where each sample costs. A grower-preformed LAMP-PCR technique was developed that requires $2,500 in capital equipment and can be performed by unskilled labor. In the first year of testing, growers were able to detect 10 spores 65 percent of the time and had 90 percent accuracy rate for field samples when compared to LAMP PCR conducted in a LAB by skilled labor and 79 percent accuracy rate to quantitative PCR. **Impact:** The LAMP-PCR procedure significantly reduces both the capital (>$42,000), expendable (>$5/sample), and labor (>$5/sample) costs associated with inoculum detection. The LAMP-PCR procedure will improve implementation of inoculum detection for time fungicide applications which has been shown to result in 2.4 fewer fungicide applications per season in commercial vineyards. (Collaborator Gary Grove)

Modeling Turbulent airflow in perennial canopies:
There is a limited understanding of the factors that influence dispersal of fungal pathogens with vineyards. Preliminary models of turbulent airflow and its effect to dispersal of fungal spores in vineyards have been developed. **Impact**: The models can be used to direct scouting and management efforts to specific areas of vineyards where disease is most likely to develop, and assist in the deployment of spore traps for monitoring airborne inoculum. They could also be used to develop a mechanistic model for grape phenology and pathogen development allowing for the in silico examination of training system and their impact on grape growth and disease development. (Collaborator Rob Stoll, Eric and Patty Skinkis)

Metagenome of grape leaves and fruit:
Understanding the membership and succession of microorganism on plant surfaces is needed in order to gain a better understanding of the effect of management, particularly organic or similar approach, on disease development and more rationally develop control programs based on the inundation of beneficial microorganism. State-of-the art pyrosequencing techniques are being used to examine the microbial communities associated with grape leaves and berries throughout the growing season

in organic and conventional vineyards in Oregon and California. **Impact:** This information will aid in the development and deployment of biocontrol agents against grape powdery mildew and botrytis bunch rot. The techniques developed to study the grape metagenome could also be used to help understand the impacts of the berry microflora on fermentation and wine composition. (Collaborators Johan Leveau, Doug Gubler)

TECHNOLOGY TRANSFER/OUTREACH:

- Conducting on farm research at 19 different commercial vineyards in Oregon.
- Established a material transfer agreement with a company to investigate the potential commercialization of an inoculum detection service. The material transferred included protocols for PCR and construction of impaction traps. They will be evaluating the qualitative and LAMP-PCR techniques for commercial use.
- Made 16 presentations to the grape industry and helped organize two workshops and presented in four workshops.

EXTERNAL SUPPORT:

- 2007. OWB. Improving powdery mildew management by modifying the Gubler/Thomas model for Oregon and developing highly sensitive disease assessment methods. Mahaffee, W. $20,580
- 2008-2010. AVF and OWB. Impacts of early season fruit zone leaf removal on disease control, fruit set, vine growth and grape and wine quality of Pinot noir. Skinkis, P and Mahaffee, W. $115,4820.
- 2009-2011. NWCSFR. Integration of mite biological control using timed miticide applications and organic and low input fungus programs. Walton, V., Dreves, A, and Mahaffee, W. $ 103,500
- 2009-2011. OWB, AVF, VCW. Development of grower preformed LAMP PCR for detection-based management programs for grapevine powdery mildew in vineyards. Mahaffee, W. and Grove, G. $120,000.
- 2010-2013. USDA-AFRI. Automated mesoscale pest risk forecast maps for agricultural production and potential plant biosecurity threats. Coop,L., Daly, C., Johnson, D., Gubler, D., Fox, A. Pfender, W., Gent, D., and Mahaffee, W. $996,111.
- 2010. USDA-NIFA. Phyllosphere 2010: Ninth International Symposium on the Microbiology of Aerial Plant Surfaces. Mahaffee, W. $12,000.
- 2010. VCW and AVF. Metagenomic diversity of plant leaf-associated microbial communities in a pathosystem context. Leveau, J. Gubler, W. and Mahaffee, W. $25,000

COLLABORATORS:

Dr. Leonard Coop, Dr. Chris Daly, Dr. Paul Jepson, and Dr. Patty Skinkis, Oregon State University, Corvallis, OR; Allan Fox, FoxWeather LLC, Fortuna, CA; Dr. David Gent and Dr. William Pfender, ARS Corvallis, OR; Dr. Gary Grove, Washington State University, Prosser, WA; Dr. Doug Gubler, Dr. Johan Leveau, and Dr. Travis Lybbret, University of California, Davis, CA; Dr. Dennis Johnson, Washington State University, Pullman, WA; Dr. Eric Pardyjak and Dr. Rob Stoll, University of Utah, Salt Lake City, UT; and Carla Thomas, National Plant Disease Network, University California, Davis.

RECENT PUBLICATIONS:

- Johnson, K.B., and Mahaffee, W.F. 2010 Factors influencing epidemiology and management of blackberry rust in cultivated *Rubus laciniatus*. Plant Disease 94:581-588.
- Gomez, D., Morin, L., Evans, K., Mahaffee, W. F. Neill, T. M., Grunwald, N. J. 2009. Development of 11 polymorphic microsatellite markers for the blackberry rust fungus *Phragmidium violaceum. Molecular Ecology Resources*
- Peetz, A.B., Mahaffee, W.F., and Gent, D.H. 2009. Effect of temperature on sporulation and infectivity of *Podosphaera macularis* on *Humulus lupulus*. Plant Disease 93: 281-286
- Gent, D.H., Turechek, W.W. and Mahaffee, W.F. 2008. Spatial and temporal stability of the estimated parameters of the binary power law. Phytopathology 98: 1107-1117
- Gent, D. H., Barbour, J. D., Grove, G. G., Mahaffee, W. F., Nelson, M. E., Ocamb, C. M., Peetz, A., and Turechek, W. W. 2007. A decade of hop powdery mildew in the Pacific Northwest. Online. Plant Health Progress doi: 10.1094 PHP-2008-0314-01-RV.
- Gent, D. H., Turechek, W. W., and Mahaffee, W. F. 2007. Sequential sampling for estimation and classification of the incidence of hop powdery mildew I: Leaf sampling. Plant Dis. 91:1002-1012.
- Gent, D. H., Turechek, W. W., and Mahaffee, W. F. 2007. Sequential sampling for estimation and classification of the incidence of hop powdery mildew II: Cone sampling. Plant Dis. 91:1013-1020.
- Falacy, J.S., Grove, G.G., Mahaffee, W. F., Larsen, R.C., Glawe, D.A. Vandemark, G.J., and Galloway, H. 2007. Detection of *Erysiphe (Uncinula) necator* using the Polymerase Chain Reaction and Species-Specific Primers. Phytopathology 97:1290-1297.